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Fourth Semester B.E. Degree Examination, Dec.09-Jan.10
Field Theory

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

Important Note: 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. 2. Any revealing of identification, appeal to evaluator and/or equations written eg, 42+8=50, will be treated as malpractice.

PART – A

1 a. Given $D = [10r^2 + 5e^{-r}]\ \hat{a}_r\ {}^{c}\!/_{m^2}$. Find the following :

i) ρ_v as a function of r

ii) The total charge enclosed by a sphere of radius a,centered at the origin. **(08 Marks)**

b. Derive an expression for electric field intensity due to circular disc of charge density $\rho_s\ {}^{c}\!/_{m^2}$. **(05 Marks)**

c. Derive an expression for electric field intensity due to an infinite line charge of linear charge density ρ_L, using Gauss law. **(07 Marks)**

2 a. Prove that $E = -\nabla V$. **(04 Marks)**

b. Determine the work done in carrying a -2μc charge from $P_1(2,1,-1)$ to $P_2(8,2,-1)$ in the field $\vec{E} = Y\hat{a}_x + x\hat{a}_y\ {}^{V}\!/_{m}$, along the parabola $x = 2y^2$. **(08 Marks)**

c. With usual notations, derive boundary conditions at the boundary between a dielectric and a conductor in an electric field. **(08 Marks)**

3 a. Using Laplace equation, derive an expression for the capacitance of a concentric spherical capacitor. **(08 Marks)**

b. State and prove uniqueness theorem. **(07 Marks)**

c. If the field of a region of space is given by $\vec{E} = \hat{a}_z(5\cos z)$, is the region free of charge? **(05 Marks)**

4 a. Given the field $\vec{H} = 20\,r^2\,\hat{a}_\phi\ {}^{A}\!/_{m}$;

i) Determine the current density $\vec{J}$.

ii) Integrate $\vec{J}$ over the circular surface r = 1, 0 < ϕ < 2π z= 0, to determine the total current passing through that surface in the $\hat{a}_z$ direction. **(08 Marks)**

b. Derive the expressions for scalar and vector magnetic potential. **(08 Marks)**

c. Prove that vector magnetic potential satisfies Poisson's equation. **(04 Marks)**

PART – B

5 a. Define self inductance and mutual inductance with suitable formulae. **(04 Marks)**

b. A solenoid with air core has 2000 turns and a length of 500mm. Core radius is 40mm. Find its inductance. Derive the formula used. **(08 Marks)**

c. For the square loop of wire in the z = 0 plane carrying 2mA in the field of an infinite filament on the Y-axis, as shown in Fig.Q5(c), calculate the total force on the loop.

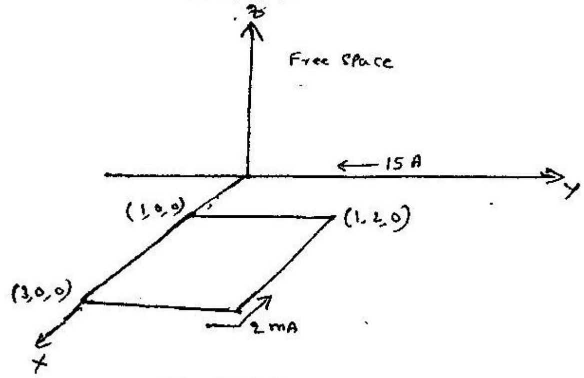

Fig.Q5(c) **(08 Marks)**

6 a. Starting from the concept of Faraday's law of electromagnetic induction, derive the Maxwell's equation, $\nabla \times E = -\frac{\partial B}{\partial t}$. **(06 Marks)**

b. Find the frequency at which conduction current density and displacement current density are equal in a medium with $\sigma = 2 \times 10^{-4}$ S/m and $\varepsilon_r = 81$. **(04 Marks)**

c. Explain the concept of retarded potentials. Derive the expressions for the same. **(10 Marks)**

7 a. A radio station transmits power radially around the spherical region. The desired electric field intensity at a distance of 10km from the station is 1 mv/m. Calculate the corresponding H, P and station power. **(06 Marks)**

b. State and prove Poynting theorem. **(06 Marks)**

c. For an electromagnetic wave, prove that $\alpha = \omega\sqrt{\frac{\mu\epsilon}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\omega\epsilon}\right)^2}-1\right]^{1/2}$ and $\beta = \omega\sqrt{\frac{\mu\epsilon}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\omega\epsilon}\right)^2}+1\right]^{1/2}$ where α = attenuation constant and β = phase constant. **(08 Marks)**

8 a. Define the terms :

i) Reflection coefficient and

ii) Transmission coefficient.

Also bring out the relation between them. **(08 Marks)**

b. Write short note on SWR. **(05 Marks)**

c. A uniform plane wave in air partially reflects from the surface of a material whose properties are unknown. Measurements of the electric field in the region in front of the interface yield 1.5m spacing between the maxima with the first maximum occurring 0.75m from the interface. A standing wave ratio of 5 is measured. Determine the intrinsic impedance of the unknown material. **(07 Marks)**

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